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(54) **Laminated heat exchanger**

Laminierter Wärmetauscher

Echangeur de chaleur laminé

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Description

[0001] The present invention relates to a laminated heat exchanger used in the cooling cycle or the like in an air conditioning system for vehicles that is constituted by laminating tube elements and fins alternately over a plurality of levels and in particular, the present invention relates to a laminated heat exchanger that adopts a structure in which a pair of tank portions are formed at one side of the tube elements and intake / outlet portions for heat exchanging medium are provided at one end in the direction of the lamination or at the end surface of the core main body in the direction of the air flow. Such a heat exchanger is known from US-A-4 821 531.

[0002] In order to respond to the demand for miniaturization of heat exchangers and to improve the heat exchanging efficiency, the applicant has developed the heat exchanger shown in FIGS. 1 and 2 and has conducted much research related to this heat exchanger. In this laminated heat exchanger, a core main body is formed by laminating tube elements alternately with fins 2 over a plurality of levels, a pair of tank portions 12 provided at one side of each tube element are made to communicate via a U-shaped passage portion 13, a heat exchanging medium flow passage with a plurality of passes is formed in the core main body by implementing communication between the tank portions 12 of adjacent tube elements as necessary, and intake / outlet portions (intake portion 4 and outlet portion 5) for the heat exchanging medium are provided at one end of the core main body in the direction of the lamination with one of these intake / outlet portions (intake portion 4) being made to communicate with a tank block 21, which constitutes one end of the heat exchanging medium flow passage through a communicating pipe 30 and the other of the intake / outlet portions (outlet portion 5) being made to communicate directly with a tank block 22, which constitutes the other end of the heat exchanging medium flow passage.

[0003] The applicant has also been conducting various types of research into the one-side tank type laminated heat exchanger that is known in the prior art, as well as the heat exchanger described above. For instance, FIGS. 10 and 11 show one such heat exchanger. In this heat exchanger, a core main body is formed by laminating tube elements alternately with fins 2 over a plurality of levels, a pair of tank portions 12, provided at one side of each tube element (toward the bottom in the figures) are made to communicate via a U-shaped passage portion 13 and the tank portions 12 in adjacent tube elements are made to communicate as necessary to form a heat exchanging medium flow passage with a plurality of passes in the core main body. In these aspects, this heat exchanger is similar to the one described earlier. However, this heat exchanger is provided with intake / outlet portions (intake portion 4, outlet portion 5) for heat exchanging medium at the end surface of the core main body in the direction of the air flow.

[0004] In these heat exchangers described above, when the heat exchanging medium flows in through one of the intake / outlet portions (intake portion 4), the heat exchanging medium enters the tank block 21 which constitutes one end of the heat exchanging medium flow passage either directly or via the communicating pipe 30. After travelling through a plurality of passes, the heat exchanging medium reaches the tank block 22, which constitutes the other end of the heat exchanging medium flow passage, and it flows out through the other of the intake / outlet portions (outlet portion 5), which communicates with the tank block 22. In this process, the flow of the heat exchanging medium, in which it travels upward or downward through the U-shaped passage portions 13 of the tube elements, is counted as one pass and, for instance, a heat exchanger in which the heat exchanging medium passes through the U-shaped passage portions 13 twice starting from the tank block constituting one end of the heat exchanging medium flow passage until it reaches the tank block constituting the other end, is referred to as a 4-pass heat exchanger and if it passes through the U-shaped passage portions three times, it is referred to as a 6-pass heat exchanger.

[0005] However, in the first type of heat exchanger, i. e., in a 4-pass cooling heat exchanger, in which the heat exchanging medium passes through a tank group without a partitioning portion 18 when it moves from the second pass to the third pass, as shown in FIG. 9A, the coolant tends to flow in the direction that runs at a right angle to the air flow in the structure described above, in which the coolant flows out from one end of the core main body. This results in the coolant collecting in the tube elements close to the outlet (one end in the direction of the lamination). In other words, in the area extending from the third pass through the fourth pass, the coolant does not readily flow toward the side close to the partitioning portion 18 and this has been proved true through testing; the results of which are indicated with the broken lines in FIGS. 7 and 8, which demonstrate that the tube temperature and the passing air temperature in the area of the partitioning portion close to the outlet are higher than those in the other areas.

[0006] In this context, the tube temperature (TUBU TEMP.) refers to the temperature of the tube element itself and the tube numbers (TUBU No.) in FIGS. 7 and 12 refer to the tube element numbers assigned starting from the front left side in FIGS. 1 and 10. Also, the passing air temperature (AIR TEMP.) refers to the temperature of the air that has passed through the area between the tube elements and for which heat exchange has been performed with the fins. The air temperature was measured at a position that is away from the end surface of the core main body on the downstream side by 1 ~ 2 cm.

[0007] In a 6-pass heat exchanger, too, the heat exchanging medium flow concentrates in the area toward the outlet side, away from the partitioning portion 18, as shown in FIG. 9B. As a result, it is assumed that the tube

temperature and the passing air temperature in the area of the partitioning portion near the outlet will be different from those in the other areas.

[0008] Furthermore, in the latter type of heat exchanger, too, i.e., a 4-pass cooling heat exchanger, when the flow speed increases with the coolant flow rate per unit time increasing, the coolant will concentrate toward the end in the direction of the lamination when it moves from the second pass through the third pass, as shown in FIG. 14, and the coolant will not readily flow in the area toward the partitioning portion 18 in the area extending from the third pass through the fourth pass. The coolant is clearly demonstrated to flow in this manner by the test results indicated with the broken lines in FIG. 12, which show that the passing air temperature is higher in the area near the partitioning portion 18 compared to the other areas.

[0009] Accordingly, it is an object of the present invention to provide a laminated heat exchanger in which heat exchanging medium can flow evenly throughout the tube elements without concentrating in any area and with which it is possible to achieve an improvement in heat exchanging efficiency.

[0010] It has been discovered that concentration of heat exchanging medium in any particular area can be prevented when the heat exchanging medium is made to flow sufficiently through the tube elements near the partitioning portion, which results in nearly consistent temperature distribution in the core main body, by changing the state of the flow of the heat exchanging medium travelling from an even-numbered pass to an odd-numbered pass in the tank group.

[0011] Thus in accordance with the invention, there is provided a heat exchanger comprising an assembly of tube elements and fins, each of said tube elements including a pair of tank portions each with a through hole and a U-shaped passage communicating between said pair of tank portions, said fins being placed between two adjacent tube elements, wherein:

a pair of tank groups is constituted by connecting said pair of tank portions and extend along the lower part of said assembly,
 said U-shaped passage has an up-flow leg through which heat exchange medium flows from one of said pair of tank portions and a down-flow leg through which said heat exchange medium flows to another of said pair of tank portions,
 each of odd-numbered passes is constituted by an odd-numbered tank subgroup including a specific number of said tank portions connected in series belonging to the same tank group and said up-flow legs of said U-shaped passages communicating with said odd-numbered tank subgroup,
 each of even-numbered passes is constituted by said down-flow legs of said U-shaped passages communicating with said up-flow legs of the preceding odd-numbered tank subgroup and an even-

numbered tank subgroup including said tank portions communicating with said down-flow legs,
 said each of even-numbered tank subgroup except for the last even-numbered tank subgroup communicates with said odd-numbered tank subgroup next to said each of even-numbered tank subgroup, and each of said tank subgroups side by side except for said even-numbered tank subgroup and said next odd-numbered tank subgroup in communication with each other is partitioned from the next tank subgroup by a partitioning portion, characterised in that:

a constricting portion for limiting the flow passage cross-section is formed in at least one tank portion located adjacent the preceding even-numbered tank subgroup in said odd-numbered tank subgroup with the exception of the first odd-numbered tank subgroup.

[0012] The laminated heat exchanger according to the present invention is constituted by laminating tube elements, each of which is provided with a pair of tank portions at one side and a U-shaped passage portion communicating between the pair of tank portions, alternately with fins over a plurality of levels, to form a core main body. A heat exchanging medium flow passage with a plurality of passes is formed in the core main body by partitioning tank groups constituted by bonding the tank portions of the tube elements as necessary. Intake / outlet portions for the heat exchanging medium are provided at one end of the core main body in the direction of the lamination with one of the intake / outlet portions being made to communicate with the tank block at one end of the heat exchanging medium flow passage via a communicating pipe and the other of the intake / outlet portions being made to communicate with the tank block constituting the other end of the heat exchanging medium flow passage at one end in the direction of the lamination. A constricting portion, which limits the flow passage cross section is provided in at least one location in the tank group where the flow path shifts from an even-numbered pass to an odd-numbered pass in the plurality of passes.

[0013] Consequently, in this structure, the heat exchanging medium flowing in through one of the intake / outlet portions, enters the tank block constituting one end of the heat exchanging medium flow passage via the communicating pipe, reaches the tank block constituting the other end of the heat exchanging medium flow passage after passing through the core main body a plurality of times and flows out from one end of this tank block in the direction of the lamination via the other of the intake / outlet portions. In this process, in the area where the flow shifts from an even-numbered pass to an odd-numbered pass, the heat exchanging medium tends to flow in greater quantity toward the outlet. However, since a constricting portion for limiting the flow passage cross section is provided in the area of the tank

group where the flow shifts from an even-numbered pass (even-numbered path) to an odd-numbered pass (odd-numbered path), the heat exchanging medium flows in sufficient quantity through the tube elements near the outlet in the partitioning portion as through the other tube elements, due to the reduced flow speed caused by the constricting portion and the like. With this, as indicated with the solid lines in FIGS. 7 and 8, large discrepancies in temperature distribution are eliminated, achieving the object described above.

[0014] Alternatively, another laminated heat exchanger which achieves the same object may be constituted by laminating tube elements, each of which is provided with a pair of tank portions at one side and a U-shaped passage portion communicating between the pair of tank portions, alternately with fins over a plurality of levels to form a core main body, with a heat exchanging medium flow passage that includes a plurality of passes formed in the core main body by partitioning tank groups constituted by bonding adjacent tank portions as necessary. Intake / outlet portions through which the heat exchanging medium flows in and out are provided in the tank blocks constituting the two ends of this heat exchanging medium flow passage in the direction running at a right angle to the direction of the lamination and a constricting portion for limiting the flow passage cross section is provided in at least one location in the tank group where the flow shifts from an even-numbered pass to an odd-numbered pass in the plurality of passes. Specifically, in this structure, the intake / outlet portion may be provided at the end surface of the tank block in the direction of the air flow (the front surface of the core main body, for instance).

[0015] In this structure, too, the heat exchanging medium which has flowed in through one of the intake / outlet portions, enters the tank block constituting one end of the heat exchanging medium flow passage, reaches the tank block constituting the other end of the heat exchanging medium flow passage after passing through the core main body a plurality of times and flows out via the other of the intake / outlet portions. During this process, in the area where the flow shifts from an even-numbered pass to an odd-numbered pass, the heat exchanging medium tends to flow in a concentrated manner away from the even-numbered pass if the flow speed is high. However, since the constricting portion for limiting the flow passage cross section is provided in the area of the tank group where the flow shifts from an even-numbered pass (even-numbered path) to an odd-numbered pass (odd-numbered path), the heat exchanging medium flows in sufficient quantity through the tube elements near the partitioning portion as through the other tube elements due to the reduced flow speed caused by the constricting portion and the like. Thus, as indicated with the solid lines in FIG. 12, there is no great discrepancy in the temperature distribution, achieving the object described earlier.

[0016] In this structure, the constricting portion is

formed in the tank group opposite the tank group which is provided the partitioning portion and it is desirable to provide the constricting portion at the position which corresponds to the position in the lamination where the partitioning portion is provided in the tank group. In addition, the constricting portion may be constituted with a plurality of holes.

[0017] While the form of the constricting portion may include many variations, it has been confirmed that, in a given area, a two-hole configuration rather than one hole, provides greater consistency in temperature distribution and, by adjusting the number of holes, their shape and size as necessary, it is possible to achieve subtle adjustments while maintaining a temperature distribution that is practically consistent. Thus, in actual use, the benefit of the structure described in claim 4 is significant. In addition, it is necessary to set an appropriate constricting portion in relation to the pressure loss and the quantity of heat discharge from the core main body. If the cross section area of the constricting portion is too small, it results in a greater pressure loss with reduced quantity of heat discharge, while if the cross section area of the constricting portion is too large, the pressure loss is reduced but uneven distribution of the heat exchanging medium, which is the problem in the prior art, becomes more pronounced. Because of this, it is desirable that the cross section area S1 of the constricting portion and the cross section area S2 of the through holes communicating between the tank portions maintain a relationship expressed as $0.25 \leq S1 / S2 \leq 0.80$.

[0018] The above and other features of the invention and the concomitant advantages will be better understood and appreciated by persons skilled in the field to which the invention pertains in view of the following description given in conjunction with the accompanying drawings which illustrate preferred embodiments. In the drawings:

FIG. 1 shows the end surface which is at a right angle to the direction of the air flow in a heat exchanger which is the first mode of the laminated heat exchanger according to the present invention;

FIG. 2A shows a side surface of the laminated heat exchanger shown in FIG. 1 where the intake / outlet portions are provided and FIG. 2B shows the bottom surface of the laminated heat exchanger shown in FIG. 1;

FIG. 3 shows formed plates constituting the tube elements used in the laminated heat exchanger, with FIG. 3A showing a normal formed plate 6a, FIG. 3B showing a formed plate 6b provided with a partitioning portion and FIG. 3C showing a formed plate 6c provided with a constricting portion;

FIGS. 4 ~ 6 show variations of the constricting portion;

FIG. 7 is a characteristics diagram showing the temperature of the tube elements in the laminated heat exchanger;

FIG. 8A is a characteristics diagram showing the temperature of the air passing through the upper portion of the laminated heat exchanger in the first mode (the representative temperature of the air passing through the upper half, between the tube elements) and FIG. 8B is a characteristics diagram showing the temperature of the air passing through the lower portion of the laminated heat exchanger in the first mode (the representative temperature of the air passing through the lower half between of the tube elements);

FIG. 9A is a conceptual diagram illustrating the flow of heat exchanging medium in a 4-pass laminated heat exchanger in the prior art, provided with intake / outlet portions for the heat exchanging medium at one end of the core main body in the direction of the lamination which is not provided with a constricting portion, and FIG. 9B is a conceptual diagram illustrating the flow of heat exchanging medium in a 6-pass laminated heat exchanger in the prior art without a constricting portion;

FIG. 10 shows the end surface which is at a right angle to the direction of the air flow in a laminated heat exchanger, which is the second mode of the laminated heat exchanger according to the present invention;

FIG. 11A shows the side surface of the laminated heat exchanger shown in FIG. 10 and FIG. 11B shows the bottom surface of the laminated heat exchanger shown in FIG. 10;

FIG. 12A is a characteristics diagram showing the temperature of the air passing through the upper portion of the laminated heat exchanger in the second mode (the representative temperature of the air passing through the upper half, between the tube elements) and FIG. 12B is a diagram showing the temperature of the air passing through the lower portion of the heat exchanger in the second mode (the representative temperature of the air passing through the lower half between the tube elements); FIG. 13 is a characteristics diagram representing the quantity of heat discharge Q from the core main body and the pressure loss ΔP_r relative to the ratio of the cross section area S_1 of the constricting portion and the cross section area S_2 of the through holes communicating between the tank portions, and

FIG. 14 is a conceptual diagram illustrating the flow of heat exchanging medium in a 4-pass laminated heat exchanger in the prior art provided with intake / outlet portions provided at the end surface of the core main body in the direction of the air flow but not provided with a constricting portion.

[0019] The following is an explanation of embodiments of the present invention in reference to the drawings. In FIGS. 1 and 2, a laminated heat exchanger 1 is a 4-pass type evaporator, for instance, with its core main

body formed by laminating fins 2 and tube elements 3 alternately over a plurality of levels and an intake portion 4 and an outlet portion 5 for heat exchanging medium provided at one end in the direction of the lamination of the tube elements 3. All the tube elements 3, except for tube elements 3a and 3b at the two ends in the direction of the lamination, the tube element 3c provided with an extended tank portion which is to be explained later, the tube element 3d located approximately at the center and the tube element 3e, which is adjacent to the tube element 3d, are each constituted by bonding two formed plates 6a, one of which is shown in FIG. 3A.

[0020] This formed plate 6a is formed by press machining an aluminum plate with two bowl-like distended portions for tank formation 7 and 7 formed at one end, a distended portion for passage formation 8 formed continuous to them, an indented portion 9 for mounting a communicating pipe, which is to be explained later, formed between the distended portions for tank formation and a projection 10 extending from the area between the two distended portions for tank formation 7 and 7 to the area close to the other end of the formed plate 6a, formed in the distended portion for passage formation 8. In addition, at the other end of the formed plate 6, a projected tab (shown in FIG. 1) for preventing the fins 2 from falling out during assembly preceding brazing, are provided.

[0021] The distended portions for tank formation 7 are made to distend more than the distended portion for passage formation 8 and the projection 10 is formed so as to lie on the same plane as the bonding margin at the edge of the formed plate. When two formed plates 6a are bonded at their edges, their projections 10 are also bonded so that a pair of tank portions 12 and 12 are formed with the distended portions for tank formation 7 that face opposite each other and a U-shaped passage portion 13 for communicating between the tank portions is formed with the distended portions for passage formation 8 that face opposite each other.

[0022] The tube elements 3a and 3b at the two ends in the direction of the lamination are each constituted by bonding a flat plate 31 to a plate 6a, illustrated in FIG. 2B.

[0023] In the formed plates 6b and 6c constituting the tube element 3c, one of the distended portions for tank formation extends so as to approach the other distended portion for tank formation. As a result, in the tube element 3c, a tank portion 12, the size of which is the same as that in the tube element 3 mentioned earlier, and a tank portion 12a, which is made to extend into and fill the indented portion, are formed. Other structural features, i.e., the distended portion for passage formation 8 formed continuous to the distended portions for tank formation, the projection 10 formed extending from the area between the distended portions for tank formation to the area close to the other end of the formed plate and the projected tab 11 for preventing the fins 2 from falling out provided at the other end of the formed plate

are identical to those in the formed plate 6 shown in FIG. 3A and their explanation is omitted here.

[0024] In this heat exchanger, as shown in FIG. 2B, adjacent tube elements are abutted at the tank portions to form two tank groups, i.e., a first tank group 15 and a second tank group 16 which extend in the direction of the lamination (at a right angle to the direction of the air flow) and in the one tank group 15, which includes the extended tank portion 12a, all the tank portions are in communication via the through holes 17 formed in the distended portions for tank formation 9, except for the formed plate 6d, located at approximately the center in the direction of the lamination. In the other tank group 16, all the tank portions are in communication via the through holes 17, without any partition.

[0025] The tube element 3d is constituted by combining the formed plate 6a shown in FIG. 3A and the formed plate 6d shown in FIG. 3B with the formed plate 6d, not provided with a through hole in one of its distended portions for tank formation 7a, and a partitioning portion 18 to partition one of the tank groups, i.e., the tank group 15, which is formed with this non-communicating portion. Note that the partitioning portion 18 may be constituted by having the adjacent tube element 3e, too, as a blind tank, which does not have a through hole, and by bonding the distended portions for tank formation without through holes in order to increase the strength or it may have a structure in which, instead of a blind tank, a thin plate is enclosed between the tube element 3d and the tube element 3e to close off the through holes communicating between the tank portions.

[0026] In addition, the tube element 3e is constituted by combining the formed plate 6a shown in FIG. 3A and the formed plate 6e shown in FIG. 3C, with a constricting portion 19, for limiting the communicating portion of the tank group 16 located opposite from the tank group 15 where the partitioning portion 18 is provided, in the formed plate 6e, which is on the side where it is bonded with the tube element 3d. As a result, the first tank group 15 is partitioned into a first tank block 21 that includes the extended tank portion 12a, and a second tank block 22 that communicates with the outlet portion 5 by the partitioning portion 18, while the non-partitioned second tank group 16 constitutes a third tank block 23, which is provided with the constricting portion 19. Note that in this embodiment, the tube elements are laminated over 27 levels with the tube element 3c positioned at the 6th level, the tube element 3d positioned at the 14th level and the tube element 3e positioned at the 15th level, counting from the right in the figure.

[0027] The constricting portion 19 is constituted of, for instance, one round hole with the flow passage cross section area (the size of the through hole 17) reduced compared to that in the other areas, as shown in FIG. 4A. In this embodiment, the diameter of the regular through hole 17 is set at $\phi 15.7\text{mm}$ and the diameter of the constricting portion is set at $\phi 12\text{mm}$, and the constricting portion 19 is provided in the formed plate 6e.

However, the constricting portion may be provided at the formed plate 6d, where the partitioning portion 18 is formed, as shown in FIG. 4B, or it may be provided at both the formed plates 6d and 6e in order to achieve increased strength.

[0028] It must be born in mind, however, that if the cross section area of the constricting portion 19 is too small, the passage resistance becomes great, increasing the pressure loss ΔP_r and resulting in reduced heat discharge (heat exchange quantity) Q due to the reduction in the flow rate of the heat exchanging medium (see FIG. 13) and that if, in order to avoid this, the cross section area of the constricting portion 19 is made too large, inconsistency in the distribution of the heat exchanging medium, which is the problem in the prior art, becomes more pronounced. Thus, in order to avoid these problems, it is desirable to set the size of the constricting portion 19 within a range in which the cross section area S_1 of the constricting portion 19 and the cross section area S_2 of the through holes 17 maintain the relationship expressed as $0.25 \leq S_1/S_2 \leq 0.80$. Consequently, when the size of the through hole is at $\phi 15.7$, as in this embodiment, it is desirable to form the constricting portion within the range of approximately $\phi 8 \sim \phi 14$.

[0029] Now, the intake portion 4 and the outlet portion 5, which are provided at one end in the direction of the lamination on the side which is further from the extended tank portion 12a, are constituted by bonding a plate for intake / outlet passage formation 24 to the flat plate 15 mentioned earlier, which constitutes an end plate, and are provided with an intake passage 25 and an outlet passage 26 respectively, formed to extend from approximately the middle of the plate 15 in the direction of the length toward the tank portions.

[0030] At the upper portion of the intake passage 25 and the outlet passage 26, an inflow port 28 and an outflow port 29 respectively are provided via a coupling 27 which secures an expansion valve. The intake passage 25 and the extended tank portion 12a are in communication with each other through a communicating passage constituted with a communicating pipe 30, which is secured in the indented portion 9 and is bonded to the hole formed in the plate 15 and a hole formed in the formed plate 6b. The second tank block 22 and the outlet passage 26 communicate with each other via a hole formed in the plate 15.

[0031] Thus, in the heat exchanger structured as described above, heat exchanging medium which has flowed in through the intake portion 4 enters the extended tank portion 12a through the communicating pipe 30, is then dispersed over the entirety of the first tank block 21 and then travels upward through the U-shaped passage portions 13 of the tube elements that correspond to the first tank block 21 along the projections 10 (first pass). Then, the heat exchanging medium makes a U-turn above the projections 10 before starting to travel downward (second pass) and it reaches the tank group on the opposite side (third tank block 23). After that the

heat exchanging medium moves horizontally to the remaining tube elements which constitute the third tank block 23 and travels upward through the U-shaped passage portions 13 of the tube elements along the projections 10 (third pass). Next, it makes a U-turn above the projections 10 before travelling downward (fourth pass) and is then led to the tank portions constituting the second tank block 22 before flowing out through the outlet portion 5. Because of this, the heat of the heat exchanging medium is communicated to the fins 2 during the process in which it flows through the U-shaped passage portions 13 constituting the first ~ fourth passes, so that heat exchange is performed with the air passing between the fins.

[0032] During this process, since the outlet portion 5 is connected to the second tank block 22 via the end of the core main body in the direction of the lamination, the flow of the heat exchanging medium moving from the second pass to the third pass would tend to concentrate toward the outlet portion as described earlier, and this might be of concern. However, with the constricting portion 19 formed in the communicating area in the third tank group 23, the heat exchanging medium is made to flow in sufficient quantity into the tube elements near the partitioning portion, too, among all the tube elements constituting the third and fourth passes. Such a change in the flow of coolant effected by providing the constricting portion 19 is assumed to be caused by the fact that the flow speed of the heat exchanging medium moving to the third pass is restricted by the constricting portion 19 and also the complex flow pattern being created with the prevention of a linear flow of the heat exchanging medium inside the second tank group 16. In any case, according to the results of tests in which the tube temperature and the passing air temperature were measured, shown in FIGS. 7 and 8, the temperature of the tube elements in the partitioning portion near the outlet (in particular TUBU Nos. 9 ~ 13) and the temperature of the air passing through the upper level of the tube elements (in particular TUBU Nos. 5 ~ 13) are lower than those in a heat exchanger without a constricting portion in the prior art, as indicated with the solid lines, achieving a consistent temperature distribution overall, and this proves that heat exchanging medium (coolant) flow is practically consistent over the entirety of the core main body without significant concentration in any particular area.

[0033] It has been confirmed that the temperature distribution changes subtly depending upon the shape of, and the number of holes in the constricting portion 19 mentioned above, whereby the flow passage area is made smaller relative to the other through holes 17. Even when the constricting portion 19 in the distended portion for tank formation 7 of the formed plate 6d provided with the partitioning portion 18 or the formed plate 6e adjacent to it, as shown in FIG. 4C or D, is made by forming holes symmetrically at two positions, in an upper area and a lower area, for instance, with the total

area of the constricting portion remaining the same, the temperature in the partitioning portion near the outlet (the tube temperature and the passing air temperature) can be further kept down, further smoothing the temperature distribution in core main body.

[0034] In addition, the constricting portion 19 is not limited to those described above and it may be constituted by forming two symmetrical holes at two locations, left and right in the distended portion for tank formation in the formed plate 6d provided with the partitioning portion 18 or the formed plate 6e adjacent to it, as shown in FIG. 5A, or it may be constituted by forming two symmetrical holes relative to a hypothetical line which inclines at approximately 45°, as shown in FIG. 5B.

[0035] The structure in which the constricting portion 19 is constituted with two holes also may include a configuration in which the two holes formed at the left and right in the distended portion for tank formation in the formed plate provided with the partitioning portion 18 or the formed plate adjacent to it, are not equal in size, as shown in FIG. 5C or FIG. 5D, or two holes of different sizes may be formed above and below each other at two positions in the distended portion for tank formation, as shown in FIG. 5E or FIG. 5F.

[0036] Further variations in the shape of the constricting portion 19 for limiting the flow passage area are conceivable and, as shown in FIG. 6A, the hole may be cross-shaped or, as shown in FIG. 6B, the constricting portion 19 may take a form in which small holes are provided at four locations, up, down, left and right. Furthermore, as shown in FIG. 6C, holes may be provided at three positions, i.e., in the upper, middle and lower parts of the distended portion for tank formation or, as shown in FIG. 6D, the constricting portion 19 may be constituted with three holes that are three sections of a circle created by dividing a circular hole into three approximately equal segments with their central angles approximately the same. Moreover, as shown in FIG. 6E, it may be constituted with four holes that are four sections of a circle divided into four equal segments with their central angles approximately the same.

[0037] In any of these forms, as long as the cross section area (when the constricting portion is constituted with a plurality of holes, the total area of the cross section areas of all the holes) S1 of the constricting portion 19 and the cross section area S2 of the through holes 17 retain the relationship expressed as $0.25 \leq S1/S2 \leq 0.80$, the advantages described earlier are achieved.

[0038] Another embodiment of the present invention is shown in FIGS. 10 and 11 and mainly, the aspects of it that are different from those in the previous embodiment are explained below, with the same reference numbers assigned to components which are identical to those in all the drawings.

[0039] This laminated heat exchanger is a 4-pass type evaporator, for instance, with an intake portion 4 and an outlet portion 5 for heat exchanging medium provided at an end surface of the core main body in the

direction of the air flow, specifically at the end surface on the upstream side. All the tube elements 3, except for the tube elements 3a and 3b at the two ends in the direction of the lamination, the tube element 3d located at approximately the center, the tube element 3e adjacent to it and tube elements 3f, each of which is formed as a unit with the intake portion 4 or the outlet portion 5, are constituted by bonding together two formed plates 6a, one of which is shown in FIG. 3A.

[0040] As all the tube elements except for the tube elements 3f are structured identically to those described earlier, their explanation is omitted here. In each tube element 3f, the distended portion for tank formation 7 on the upstream side projects out and opens in the direction of the air flow and, as a result, in the tube elements 3f, the intake portion 4 or the outlet portion 5 is formed by bonding this portion that projects out and opens, face-to-face. The other structural features, i.e., the distended portion for passage formation formed continuous to the distended portions for tank formation, the projection formed extending from the area between the distended portions for tank formation through the area near the other end of the formed plate and the projected tab for preventing the fins 2 from falling out provided at the other end of the formed plate are identical to those in the formed plate 6 shown in FIG. 3A and their explanation is omitted here.

[0041] In addition, the partitioning portion 18 and the constricting portion 19 provided on the opposite side from the partitioning portion 18, are structured identically to those described earlier. However, in this heat exchanger, the tube elements are laminated over 26 levels with the intake portion 4 formed at the 7th level and the outlet portion formed at the 20th level from the left in the figure, and the partitioning portion 18 and the constricting portion 19 formed between the 7th level (tube element 3e) and the 14th level (tube element 3d) counting from the left. In this heat exchanger, the partitioning portion 18 and the constricting portion 19 may be formed between the 14th level and the 15th level from the left instead.

[0042] As shown in FIG. 4A, the constricting portion 19 may be constituted by forming one round hole whose flow passage cross section is constricted in the formed plate 6e, for instance. Alternatively, this round hole may be provided in the formed plate 6d, where the partitioning portion 18 is formed, as shown in FIG. 4B, or a round hole may be provided in both the formed plates 6d and 6e for increased strength. In addition, while the diameter of the round hole is set at ϕ 12mm against the diameter of the regular through hole 17 which is set at ϕ 15.7mm, it is desirable to set the cross section area of this constricting portion within the range in which the cross section area S1 of the constricting portion 19 and the cross section area S2 of the through hole 17 retain the relationship expressed as $0.25 \leq S1/S2 \leq 0.80$ by taking into consideration the relationship illustrated in FIG. 13, as explained earlier and when the size of the through

hole is at ϕ 15.7 as in this embodiment, the constricting portion 19 may be formed within the range of approximately ϕ 8 ~ 14.

[0043] Consequently, in the heat exchanger structured as described above, heat exchanging medium which has flowed in through the intake portion 4 is distributed over the entirety of the first tank block 21 and it then travels upward through the U-shaped passage portions 13 of the tube elements that correspond to the first tank block 21 along the projections 10 (first pass). Then, it makes a U-turn above the projections 10 before travelling downward (second pass) to reach the tank group (third tank block 23) on the opposite side. After this, the heat exchanging medium moves horizontally to the remaining tube elements constituting the third tank block 23 and travels upward through the U-shaped passage portions 13 of the tube elements along the projections 10 (third pass). Then it makes a U-turn above the projections 10 before travelling downward (fourth pass) and is then led to the tank portions constituting the second tank block 22 before flowing out through the outlet portion 5. Because of this, the heat of the heat exchanging medium is communicated to the fins 2 during the process in which it flows through the U-shaped passage portions 13 constituting the first ~ fourth passes so that heat exchange is performed with the air passing between the fins.

[0044] During this process, the flow of the heat exchanging medium moving from the second pass to the third pass tends to concentrate toward the outlet portion as described earlier and this might be of concern. However, with the constricting portion 19 formed in the communicating area in the third tank group 23, the heat exchanging medium is made to flow in sufficient quantity into the tube elements near the partitioning portion, too, among all the tube elements constituting the third and fourth passes. Such a change in the flow of coolant effected by providing the constricting portion 19 is assumed to be caused by fact that the flow speed of the heat exchanging medium moving to the third pass is reduced by the constricting portion 19 and also the complex flow pattern being created with the prevention of a linear flow of the heat exchanging medium inside the second tank group 16. In any case, according to the results of tests in which the passing air temperature was measured, shown in FIG. 12, the temperature of the air passing between the tube elements of the partitioning portion near the outlet (in particular TUBU Nos. 14 ~ 20) is lower than that in a heat exchanger without a constricting portion in the prior art, as indicated with the solid line, achieving consistent temperature distribution overall. This proves that the flow of heat exchanging medium (coolant) is practically consistently over the entirety of the core main body without concentrating much in any particular area

[0045] As in the previous embodiment, it has been confirmed that when the flow passage area of the constricting portion 19 mentioned above is made smaller

relative to the other through holes 17, the temperature distribution changes subtly, depending upon its shape and the number of holes in it. Even when the constricting portion 19 is made by forming holes symmetrically at two positions above and below each other, or in the upper area and lower area of the distended portion for tank formation 7 of the formed plate 6d provided with the partitioning portion or the formed plate 6e adjacent to it, as shown in FIG. 4C or FIG. 4D, and the flow passage area remains constant, the temperature in the partitioning portion 18 near the outlet portion (the tube temperature and the passing air temperature) can be further kept down, providing an even smoother temperature distribution in the core main body.

[0046] In addition, the constricting portion 19 is not limited to those described above and may be constituted by forming two symmetrical holes at two locations, left and right, in the distended portion for tank formation in the formed plate 6d provided with the partitioning portion 18 or the formed plate 6e adjacent to it, as shown in FIG. 5A, or it may be constituted by forming two symmetrical holes relative to a hypothetical line which inclines at approximately 45°, as shown in FIG. 5B.

[0047] The structure in which the constricting portion 19 is constituted with two holes also may include one in which two holes of different size are formed at the left and right in the distended portion for tank formation in the formed plate provided with the partitioning portion 18 or the formed plate adjacent to it, as shown in FIG. 5C or FIG. 5D, or two holes of different size may be formed above and below each other at two positions in the distended portion for tank formation, as shown in FIG. 5E or FIG. 5F.

[0048] Further variations in the shape of the constricting portion 19 for limiting the flow passage area are conceivable and, as shown in FIG. 6A, the hole may be a cross-shaped or, as shown in FIG. 6B, the constricting portion 19 may take a form in which small holes are provided at four locations, up, down, left and right. Furthermore, as shown in FIG. 6C, holes may be provided at three positions, i.e., in the upper, middle and lower parts of the distended portion for tank formation or, as shown in FIG. 6D, the constricting portion 19 may be constituted with three holes that are three sections created by dividing a circular hole into three approximately equal segments with their central angles approximately the same. Moreover, as shown in FIG. 6E, it may be constituted with four holes that are four sections of a circle divided into four equal segments with their central angles approximately the same.

[0049] In any of these forms, as long as the cross section area (when the constricting portion is constituted with a plurality of holes, the total area of the cross section areas of all the holes) S1 of the constricting portion 19 and the cross section area S2 of the through holes 17 retain the relationship expressed as $0.25 \leq S1/S2 \leq 0.80$, the advantages described earlier are achieved.

[0050] Note that while the state of the flow of heat ex-

changing medium is presumably also affected by the positions of the intake portion 4 and the outlet portion 5 and in particular by the position of the outlet portion 5, since the heat exchanging medium will tend to flow near the partitioning portion even without a constricting portion 19, as long as the outlet portion 5 is located close to the partitioning portion 18, this mode of the present invention is effective, specifically, when the outlet portion 5 is provided at a position within 3/4 of the distance from the end to the partitioning portion 18 (in this embodiment, at any one of the tube elements TUBU Nos. 18 ~ 26).

[0051] As has been explained, according to the present invention, whether in a heat exchanger with the intake / outlet portions for heat exchanging medium provided at one end of the core main body in the direction of the lamination or in a heat exchanger with its intake / outlet portions provided in the direction running at a right angle to the direction of the lamination in the core main body, since a constricting portion is provided in the area where the flow of the heat exchanging medium shifts from an even-numbered pass to an odd-numbered pass where the flow tends to become uneven, more specifically, at a position which corresponds to the position of the partitioning portion which is partitioned to form a plurality of passes relative to the direction of the lamination in the tank group that is opposite the tank group in which the partitioned portion is provided to ensure that the heat exchanging medium flows in sufficient quantity into the tube elements near the partitioned portion, the uneven flow of the heat exchanging medium is prevented, achieving an improvement in heat exchanging efficiency.

Claims

1. A heat exchanger comprising an assembly of tube elements (3) and fins (2), each of said tube elements (3) including a pair of tank portions (12) each with a through hole (17) and a U-shaped passage (13) communicating between said pair of tank portions (12), said fins being placed between two adjacent tube elements (3), wherein:

a pair of tank groups (15, 16) is constituted by connecting said pair of tank portions (12) and extend along the lower part of said assembly, said U-shaped passage (13) has an up-flow leg through which heat exchange medium flows from one of said pair of tank portions (12) and a down-flow leg through which said heat exchange medium flows to another of said pair of tank portions (12),

each of odd-numbered passes is constituted by an odd-numbered tank subgroup including a specific number of said tank portions (12) connected in series belonging to the same tank

group and said up-flow legs of said U-shaped passages (13) communicating with said odd-numbered tank subgroup,

each of even-numbered passes is constituted by said down-flow legs of said U-shaped passages (13) communicating with said up-flow legs of the preceding odd-numbered tank subgroup and an even-numbered tank subgroup including said tank portions (12) communicating with said down-flow legs,

said each of even-numbered tank subgroup except for the last even-numbered tank subgroup communicates with said odd-numbered tank subgroup next to said each of even-numbered tank subgroup, and

each of said tank subgroups side by side except for said even-numbered tank subgroup and said next odd-numbered tank subgroup in communication with each other is partitioned from the next tank subgroup by a partitioning portion (18), characterised in that:

a constricting portion (19) for limiting the flow passage cross-section is formed in at least one tank portion located adjacent the preceding even-numbered tank subgroup in said odd-numbered tank subgroup with the exception of the first odd-numbered tank subgroup.

2. A heat exchanger as claimed in Claim 1, wherein:

an intake portion (4) and an outlet portion (5) are mounted on one of both sides of said assembly perpendicular to the direction in which said pair of tank groups (15, 16) extends, the first one of said odd-numbered tank subgroups has an extended tank portion (12a), said intake portion (4) communicates with said extended tank portion (12a) via a communication pipe (30), and said outlet portion (5) communicates with the last one of said even-numbered tank subgroups.

3. A heat exchanger as claimed in Claim 2, wherein:

the number of said passes is four, one of said tank group (15) has the first tank subgroup and the fourth tank subgroup, said partitioning portion (18) being positioned between the first tank subgroup and the fourth tank subgroup to partition each other, the first tank subgroup having said extended tank portion (12a), another of said tank group (16) has the second tank subgroup and the third tank subgroup, the second tank subgroup and the third tank subgroup being in communication with each other, and

the constricting portion (19) being formed in at least one tank portion located adjacent the second tank subgroup in the third tank subgroup.

4. A heat exchanger as claimed in Claim 2, wherein:

the number of said passes is six, one of said tank group (15) has the first tank subgroup, the fourth tank subgroup and the fifth tank subgroup, said partitioning portion (18) being positioned between the first tank subgroup and the fourth tank subgroup to partition each other, the fourth tank subgroup and the fifth tank subgroup being in communication with each other, the first tank subgroup having said extended tank portion (12a), another of said tank group (16) has the second tank subgroup, the third tank subgroup and the sixth tank subgroup, the second tank subgroup and the third tank subgroup being in communication with each other, said partitioning portion (18) being positioned between the third tank subgroup and the sixth tank subgroup to partition each other, and said constricting portions (19) are formed in at least one tank portion located adjacent the second tank subgroup in third tank subgroup and in at least one tank portion located adjacent the fourth tank subgroup in the fifth tank subgroup.

5. A heat exchanger as claimed in Claim 1, wherein:

the number of said passes is four, one of said tank group (15) has the first tank subgroup and the fourth tank subgroup, said partitioning portion (18) being positioned between the first tank subgroup and the fourth tank subgroup to partition each other, another of said tank group (16) has the second tank subgroup and the third tank subgroup, the second tank subgroup and the third tank subgroup being in communication with each other, said intake portion (4) is formed in one tank portion located at approximately the centre of said first tank subgroup, said outlet portion (5) is formed in one tank portion located at approximately the centre of said fourth tank subgroup, and said constricting portion (19) being formed in a through hole (17) in at least one tank portion located adjacent the second tank subgroup in the third tank subgroup.

6. A heat exchanger as claimed in any one of Claims 1 to 5, wherein

said constricting portion (19) is constituted by a restriction in a through hole (17) whose area is smaller than the area of the other through hole (17).

7. A heat exchanger as claimed in any one of Claims 1 to 5, wherein said constricting portion (19) is constituted by holes whose total area is smaller than the area of the other through hole (17). 5
8. A heat exchanger as claimed in Claim 7, wherein said holes are positioned symmetrically.
9. A heat exchanger as claimed in Claim 7, wherein said holes are formed in different sizes. 10
10. A heat exchanger as claimed in any preceding claim, wherein when the area of said constricting portion (19) is S1, and the area of said through hole (17) is S2, the relationship of S1 and S2 is expressed as: $0.25 \leq S1/S2 \leq 0.80$. 15
11. A heat exchanger as claimed in Claim 6, wherein when the diameter of said through hole (17) is 15.7mm, the diameter of the hole of the constricting portion (19) is in the range of from 8 to 14mm. 20

Patentansprüche 25

1. Wärmetauscher, aufweisend eine Anordnung von Rohrleitungselementen (3) und Kühlrippen (2), wobei jedes der Rohrleitungselemente (3) zwei Behälterteile (12) mit jeweils einer Durchgangsöffnung (17) und einem U-förmigen Durchflußkanal (13) hat, der die zwei Behälterteile (12) miteinander verbindet, wobei die Kühlrippen zwischen zwei benachbarten Rohrleitungselementen (3) angeordnet sind, bei dem: 30
- zwei Behältergruppen (15, 16) durch das Verbinden der zwei Behälterteile (12) gebildet sind und sich entlang des unteren Abschnitts der Anordnung erstrecken, 40
 - der U-förmige Durchflußkanal (13) einen Aufwärtsströmungsschenkel hat, durch den das Wärmeaustauschmittel von einem der zwei Behälterteile (12) fließt, und einen Abwärtsströmungsschenkel hat, durch den das Wärmeaustauschmittel zu einem weiteren der zwei Behälterteile (12) fließt, 45
 - jeder von ungeradzahigen Durchgangskanäle von einer ungeradzahigen Behälteruntergruppe gebildet ist, die eine bestimmte Anzahl von in Reihe geschalteten Behälterteilen (12) hat, die derselben Behältergruppe angehören, und die Aufwärtsströmungsschenkel der U-förmigen Durchflußkanäle (13) mit der ungeradzahigen Behälteruntergruppe in Verbindung stehen, 50
 - jeder von geradzahigen Durchflußkanäle durch die Abwärtsströmungsschenkel der U-

- förmigen Durchflußkanäle (13), die mit den Aufwärtsströmungsschenkeln der vorhergehenden ungeradzahigen Behälteruntergruppe in Verbindung stehen, und einer geradzahigen Behälteruntergruppe, die die Behälterteile (12) umfasst, die mit den Abwärtsströmungsschenkeln in Verbindung stehen, gebildet ist,
- jede der geradzahigen Behälteruntergruppen mit Ausnahme der letzten geradzahigen Behälteruntergruppe mit der ungeradzahigen Behälteruntergruppe, die sich neben jeder der geradzahigen Behälteruntergruppen befindet, in Verbindung steht, und
 - jede der Behälteruntergruppen, die sich nebeneinander befinden, mit Ausnahme der geradzahigen Behälteruntergruppe und der benachbarten ungeradzahigen Behälteruntergruppe, die miteinander in Verbindung stehen, durch eine Trennwand (18) von der nächsten Behälteruntergruppe getrennt sind,

dadurch gekennzeichnet, dass

ein verengender Abschnitt (19) zum Begrenzen des Querschnitts des Durchflußkanals in wenigstens einem Behälterteil gebildet wird, der benachbart zu der vorhergehenden geradzahigen Behälteruntergruppe in der ungeradzahigen Behälteruntergruppe mit Ausnahme der ersten ungeradzahigen Behälteruntergruppe angeordnet ist.

2. Wärmetauscher nach Anspruch 1, bei dem:

- ein Zuflußteil (4) und ein Abflußteil (5) an einer der beiden Seiten der Anordnung senkrecht zur Richtung, in der sich die beiden Behältergruppen (15, 16) erstrecken, befestigt sind,
- die erste der ungeradzahigen Behälteruntergruppen ein verlängertes Behälterteil (12a) hat, das Zuflußteil (4) mit dem verlängerten Behälterteil (12a) über eine Verbindungsleitung (30) in Verbindung steht, und
- das Ausflußteil (5) mit der letzten der geradzahigen Behälteruntergruppen in Verbindung steht.

3. Wärmetauscher nach Anspruch 2, bei dem:

- die Anzahl der Durchflußkanäle vier ist,
- die eine Behältergruppe (15) die erste Behälteruntergruppe und die vierte Behälteruntergruppe hat, wobei die Trennwand (18) zwischen der ersten Behälteruntergruppe und der vierten Behälteruntergruppe angeordnet ist, um sie voneinander zu trennen, und wobei die erste Behälteruntergruppe das verlängerte Behälterteil (12a) hat,
- die andere Behältergruppe (16) die zweite Behälteruntergruppe und die dritte Behälterunter-

- gruppe hat, wobei die zweite Behälteruntergruppe und die dritte Behälteruntergruppe miteinander in Verbindung stehen, und
- das verengende Teil (19) in wenigstens einem Behälterteil, der der zweiten Behälteruntergruppe in der dritten Behälteruntergruppe benachbart ist, gebildet ist.
4. Wärmetauscher nach Anspruch 2, bei dem:
- die Anzahl der Durchflußkanäle sechs ist,
 - die eine Behältergruppe (15) die erste Behälteruntergruppe, die vierte Behälteruntergruppe und die fünfte Behälteruntergruppe hat, wobei die Trennwand (18) zwischen der ersten Behälteruntergruppe und der vierten Behälteruntergruppe angeordnet ist, um sie voneinander zu trennen, wobei die vierte Behälteruntergruppe und die fünfte Behälteruntergruppe miteinander in Verbindung stehen, und wobei die erste Behälteruntergruppe das verlängerte Behälterteil (12a) hat,
 - die andere Behältergruppe (16) die zweite Behälteruntergruppe, die dritte Behälteruntergruppe und die sechste Behälteruntergruppe hat, wobei die zweite Behälteruntergruppe und die dritte Behälteruntergruppe miteinander in Verbindung stehen, und wobei die Trennwand (18) zwischen der dritten Behälteruntergruppe und der sechsten Behälteruntergruppe angeordnet ist, um sie voneinander zu trennen, und
 - die verengenden Teile (19) in wenigstens einem Behälterteil, der benachbart zur zweiten Behälteruntergruppe in der dritten Behälteruntergruppe angeordnet ist und in wenigstens einem Behälterteil, der benachbart zur vierten Behälteruntergruppe in der fünften Behälteruntergruppe angeordnet ist, gebildet ist.
5. Wärmetauscher nach Anspruch 1, bei dem
- die Anzahl der Durchflußkanäle vier ist,
 - die eine Behältergruppe (15) die erste Behälteruntergruppe und die vierte Behälteruntergruppe hat, wobei die Trennwand (18) zwischen der ersten Behälteruntergruppe und der vierten Behälteruntergruppe angeordnet ist, um sie voneinander zu trennen,
 - die andere Behältergruppe (16) die zweite Behälteruntergruppe und die dritte Behälteruntergruppe hat, wobei die zweite Behälteruntergruppe und die dritte Behälteruntergruppe miteinander in Verbindung stehen,
 - das Zuflußteil (4) in einem Behälterteil, der annähernd in der Mitte der ersten Behälteruntergruppe angeordnet ist, gebildet ist,
 - das Abflußteil (5) in einem Behälterteil, der annähernd in der Mitte der vierten Behälteruntergruppe angeordnet ist, gebildet ist, und
- der verengende Abschnitt (19) in einer Durchgangsöffnung (17) in wenigstens einem Behälterteil, der benachbart zur zweiten Behälteruntergruppe in der dritten Behälteruntergruppe angeordnet ist, gebildet ist.
6. Wärmetauscher nach einen der Ansprüche 1 bis 5, bei dem der verengende Abschnitt (19) durch eine räumliche Verengung in einer Durchgangsöffnung (17) gebildet ist, dessen Querschnittsfläche kleiner ist als die Querschnittsfläche der anderen Durchgangsöffnungen (17).
7. Wärmetauscher nach einen der Ansprüche 1 bis 5, bei dem der verengende Abschnitt (19) durch Öffnungen gebildet ist, deren Gesamtquerschnittsfläche kleiner ist als die Querschnittsfläche der anderen Durchgangsöffnungen (17).
8. Wärmetauscher nach Anspruch 7, bei dem die Öffnungen symmetrisch angeordnet sind.
9. Wärmetauscher nach Anspruch 7, bei dem die Öffnungen in verschiedenen Größen gebildet sind.
10. Wärmetauscher nach einen der vorhergehenden Ansprüche, bei dem, wenn die Querschnittsfläche des verengenden Teils (19) S_1 ist, und die Querschnittsfläche der Durchgangsöffnungen (17) S_2 ist, die Beziehung von S_1 zu S_2 ausgedrückt ist in: $0,25 \leq S_1/S_2 \leq 0,80$.
11. Wärmetauscher nach Anspruch 6, bei dem, wenn der Durchmesser der Durchgangsöffnung (17) 15,7mm beträgt, der Durchmesser der Öffnung des verengenden Teils (19) in einem Bereich von 8 bis 14mm liegt.

Revendications

1. Echangeur de chaleur comprenant un ensemble d'éléments formant tubes (3) et d'ailettes (2), chacun desdits éléments formant tubes (3) comprenant deux parties formant réservoirs (12) munies chacune d'un trou traversant (17) et d'un passage en forme de U (13) établissant une communication entre lesdites deux parties formant réservoirs (12), lesdites ailettes étant placées entre deux éléments formant tubes (3) adjacents, dans lequel :

deux groupes de réservoirs (15, 16) sont constitués par la liaison desdites deux parties formant réservoirs (12) et s'étendent le long de la

partie inférieure dudit ensemble,
 ledit passage en forme de U (13) comporte une
 branche d'écoulement ascendant à travers la-
 quelle un agent d'échange thermique circule à
 partir de l'une desdites deux parties formant ré-
 servoirs (12), et une branche d'écoulement
 descendant à travers laquelle ledit agent
 d'échange thermique circule en direction de
 l'autre desdites deux parties formant réservoirs
 (12),

chacune de passes impaires est constituée par
 un sous-groupe de réservoirs impairs compren-
 nant un nombre spécifique desdites parties for-
 mant réservoirs (12) reliées en série et appar-
 tenant au même groupe de réservoirs et par
 lesdites branches d'écoulement ascendant
 desdits passages en forme de U (13) commu-
 niquant avec ledit sous-groupe de réservoirs
 impairs,

chacune de passes paires est constituée par
 lesdites branches d'écoulement descendant
 desdits passages en forme de U (13) qui com-
 muniquent avec lesdites branches d'écoule-
 ment ascendant du sous-groupe de réservoirs
 impairs précédent et par un sous-groupe de ré-
 servoirs pairs comprenant lesdites parties for-
 mant réservoirs (12) qui communiquent avec
 lesdites branches d'écoulement descendant,
 chaque sous-groupe de réservoirs pairs, à l'ex-
 ception du dernier sous-groupe de réservoirs
 pairs, communique avec ledit sous-groupe de
 réservoirs impairs qui le suit, et

chacun desdits sous-groupes de réservoirs dis-
 posés côte à côte, à l'exception dudit sous-
 groupe de réservoirs pairs et dudit sous-groupe
 de réservoirs impairs suivant en communica-
 tion l'un avec l'autre, est séparé du sous-grou-
 pe de réservoirs suivant par une partie de sé-
 paration (18), caractérisé en ce que :

une partie d'étranglement (19) destinée à
 limiter la section de passage d'écoulement est
 formée dans au moins une partie formant ré-
 servoir dudit sous-groupe de réservoirs impairs
 située à proximité du sous-groupe de résér-
 voirs pairs précédent, à l'exception du premier
 sous-groupe de réservoirs impairs.

2. Echangeur de chaleur tel que défini dans la reven- dication 1, dans lequel :

une partie d'entrée (4) et une partie de sortie
 (5) sont montées sur l'un des deux côtés dudit
 ensemble, perpendiculairement à la direction
 dans laquelle lesdits deux groupes de résér-
 voirs (15, 16) s'étendent,
 le premier desdits sous-groupes de réservoirs
 impairs comporte une partie formant réservoir
 étendu (12a),

ladite partie d'entrée (4) communique avec la-
 dite partie formant réservoir étendu (12a) par
 l'intermédiaire d'un tuyau de communication
 (30), et

ladite partie de sortie (5) communique avec le
 dernier desdits sous-groupes de réservoirs
 pairs.

3. Echangeur de chaleur tel que défini dans la reven- dication 2, dans lequel :

le nombre desdites passes est de quatre,
 l'un (15) desdits groupes de réservoirs compor-
 te le premier sous-groupe de réservoirs et le
 quatrième sous-groupe de réservoirs, ladite
 partie de séparation (18) étant positionnée en-
 tre le premier sous-groupe de réservoirs et le
 quatrième sous-groupe de réservoirs pour les
 séparer l'un de l'autre, et le premier sous-grou-
 pe de réservoirs comportant ladite partie for-
 mant réservoir étendu (12a),

l'autre (16) desdits groupes de réservoirs com-
 porte le deuxième sous-groupe de réservoirs et
 le troisième sous-groupe de réservoirs, le
 deuxième sous-groupe de réservoirs et le troi-
 sième sous-groupe de réservoirs étant en com-
 munication l'un avec l'autre, et

la partie d'étranglement (19) est formée dans
 au moins une partie formant réservoir du troi-
 sième sous-groupe de réservoirs située à
 proximité du deuxième sous-groupe de résér-
 voirs.

4. Echangeur de chaleur tel que défini dans la reven- dication 2, dans lequel :

le nombre desdites passes est de six,
 l'un (15) desdits groupes de réservoirs compor-
 te le premier sous-groupe de réservoirs, le qua-
 trième sous-groupe de réservoirs et le cinquiè-
 me sous-groupe de réservoirs, ladite partie de
 séparation (18) étant positionnée entre le pre-
 mier sous-groupe de réservoirs et le quatrième
 sous-groupe de réservoirs pour les séparer l'un
 de l'autre, le quatrième sous-groupe de résér-
 voirs et le cinquième sous-groupe de réservoirs
 étant en communication l'un avec l'autre, et le
 premier sous-groupe de réservoirs comportant
 ladite partie formant réservoir étendu (12a),
 l'autre (16) desdits groupes de réservoirs com-
 porte le deuxième sous-groupe de réservoirs,
 le troisième sous-groupe de réservoirs et le
 sixième sous-groupe de réservoirs, le deuxiè-
 me sous-groupe de réservoirs et le troisième
 sous-groupe de réservoirs étant en communi-
 cation l'un avec l'autre, et ladite partie de sépa-
 ration (18) étant positionnée entre le troisième
 sous-groupe de réservoirs et le sixième sous-

groupe de réservoirs pour les séparer l'un de l'autre, et
lesdites-parties d'étranglement (19) sont formées dans au moins une partie formant réservoir du troisième sous-groupe de réservoirs située à proximité du deuxième sous-groupe de réservoirs et dans au moins une partie formant réservoir du cinquième sous-groupe de réservoirs située à proximité du quatrième sous-groupe de réservoirs.

5. Échangeur de chaleur tel que défini dans la revendication 1, dans lequel :

le nombre desdites passes est de quatre, l'un (15) desdits groupes de réservoirs comporte le premier sous-groupe de réservoirs et le quatrième sous-groupe de réservoirs, ladite partie de séparation (18) étant positionnée entre le premier sous-groupe de réservoirs et le quatrième sous-groupe de réservoirs pour les séparer l'un de l'autre,
l'autre (16) desdits groupes de réservoirs comporte le deuxième sous-groupe de réservoirs et le troisième sous-groupe de réservoirs, le deuxième sous-groupe de réservoirs et le troisième sous-groupe de réservoirs étant en communication l'un avec l'autre,
ladite partie d'entrée (4) est formée dans une partie formant réservoir située approximativement au centre dudit premier sous-groupe de réservoirs,
ladite partie de sortie (5) est formée dans une partie formant réservoir située approximativement au centre dudit quatrième sous-groupe de réservoirs, et
ladite partie d'étranglement (19) est formée dans un trou traversant (17) défini dans au moins une partie formant réservoir du troisième sous-groupe de réservoirs située à proximité du deuxième sous-groupe de réservoirs.

6. Échangeur de chaleur tel que défini dans l'une quelconque des revendications 1 à 5, dans lequel ladite partie d'étranglement (19) est constituée par un rétrécissement formé dans un trou traversant (17), rétrécissement dont la surface est inférieure à la surface de l'autre trou traversant (17).
7. Échangeur de chaleur tel que défini dans l'une quelconque des revendications 1 à 5, dans lequel ladite partie d'étranglement (19) est constituée par des trous dont la surface totale est inférieure à la surface de l'autre trou traversant (17).
8. Échangeur de chaleur tel que défini dans la revendication 7, dans lequel lesdits trous sont positionnés de manière symétrique.

9. Échangeur de chaleur tel que défini dans la revendication 7, dans lequel lesdits trous sont formés suivant des tailles différentes.

10. Échangeur de chaleur tel que défini dans l'une quelconque des revendications précédentes, dans lequel lorsque la surface de ladite partie d'étranglement (19) est S1, et la surface dudit trou traversant (17) S2, le rapport de S1 et S2 est exprimé par : $0,25 \leq S1/S2 \leq 0,80$.

11. Échangeur de chaleur tel que défini dans la revendication 6, dans lequel lorsque le diamètre dudit trou traversant (17) est de 15,7mm, le diamètre du trou de la partie d'étranglement (19) se situe dans la plage de 8 à 14mm.

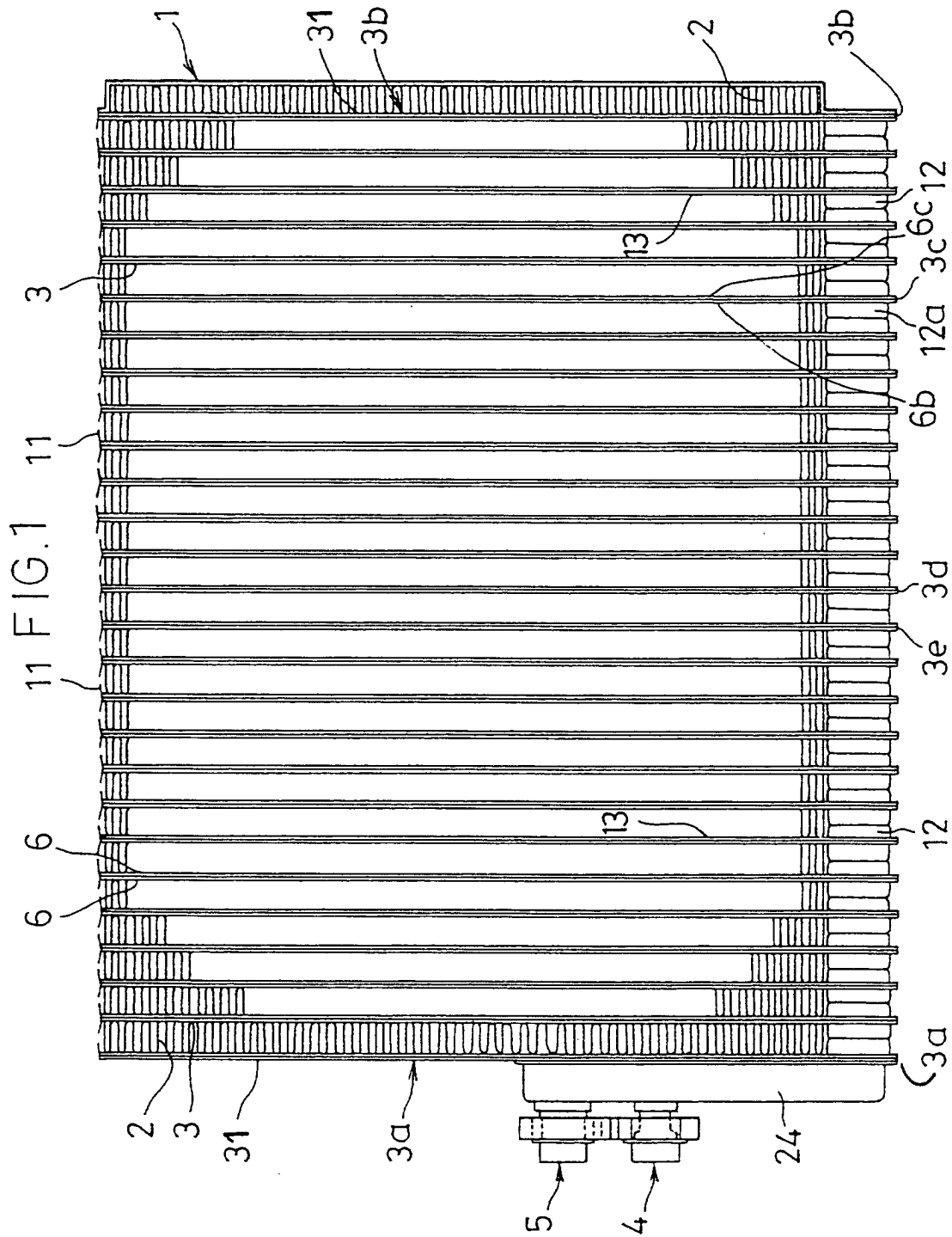


FIG.2A

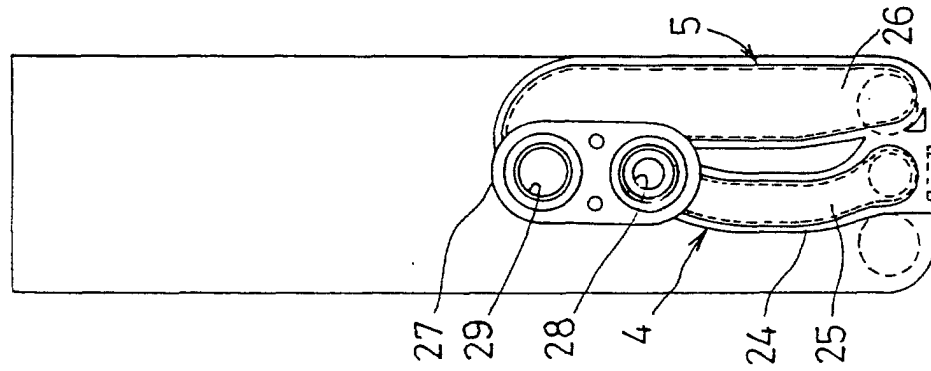
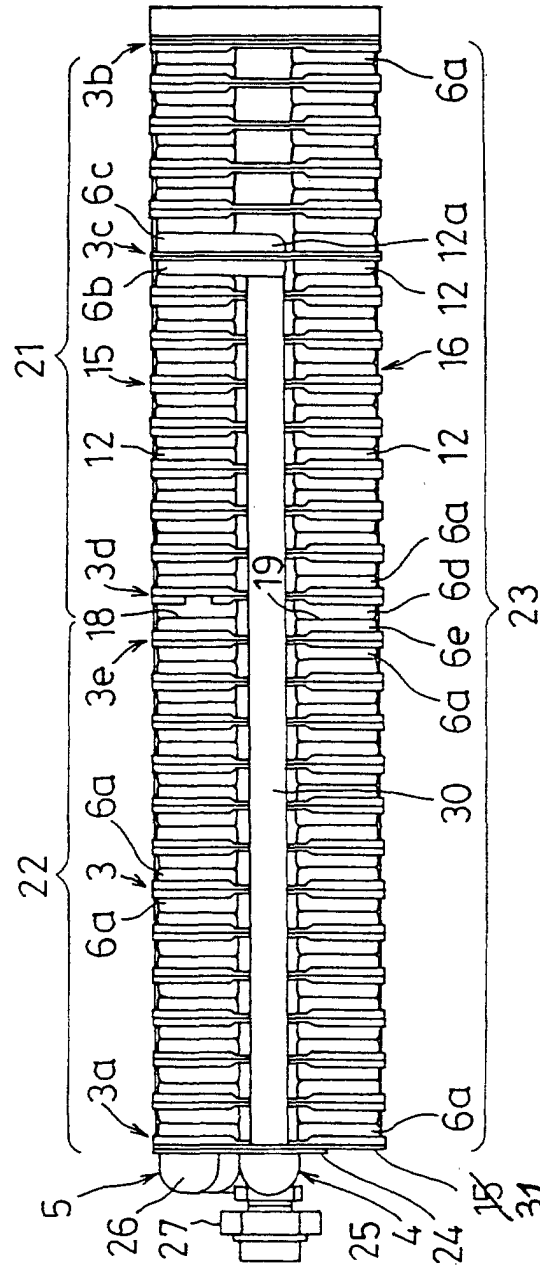


FIG.2B



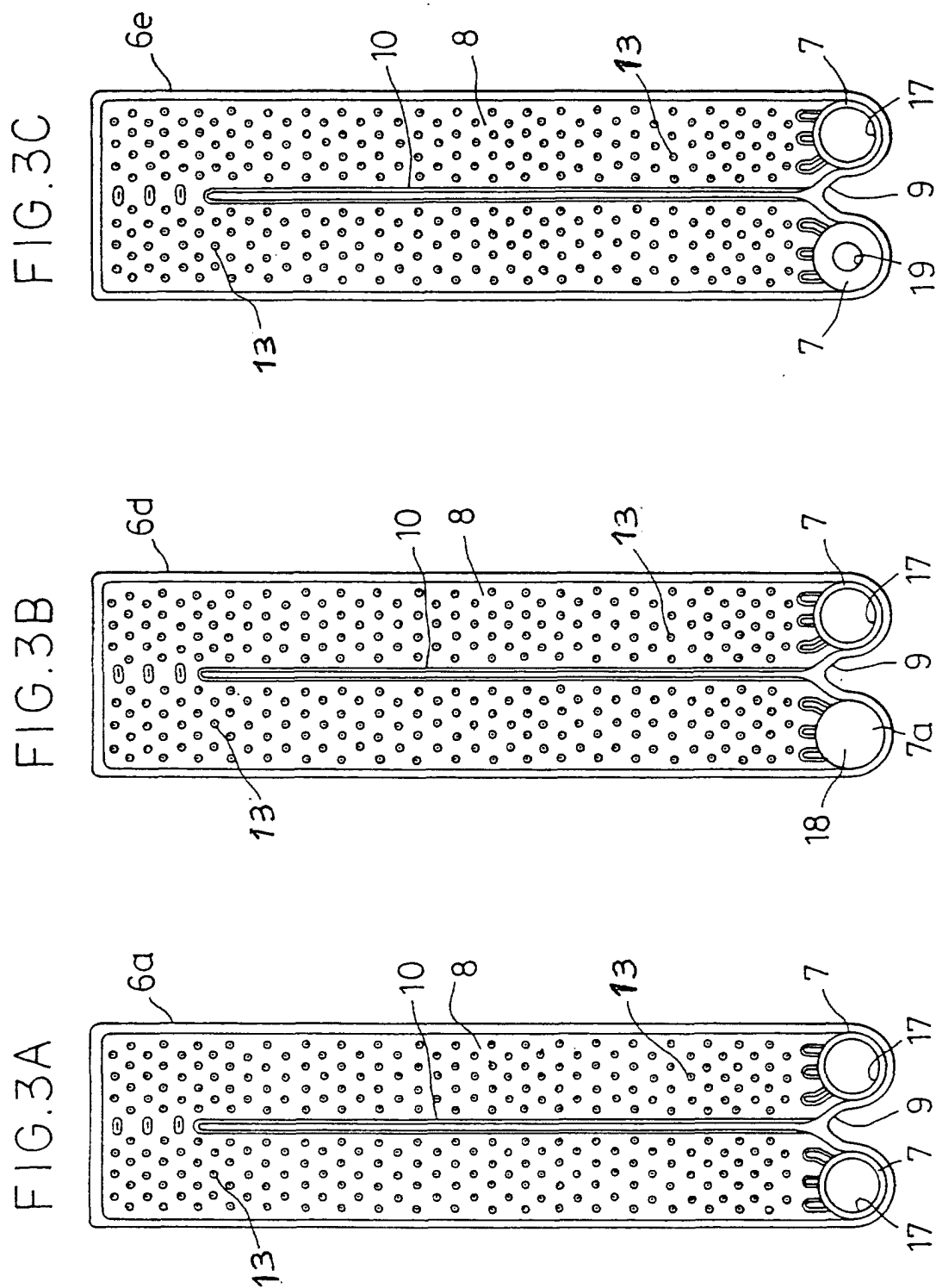


FIG.4A

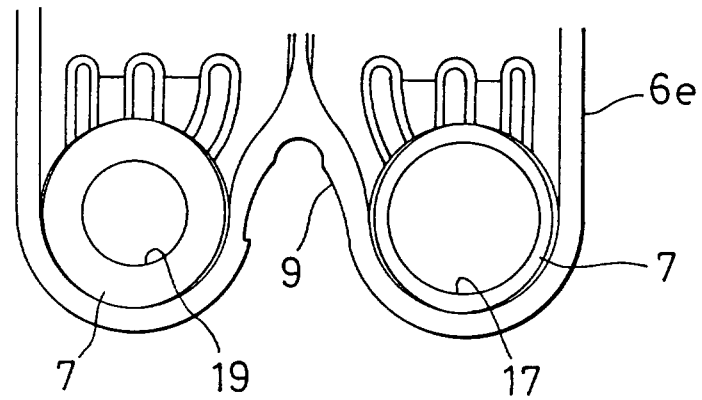


FIG.4B

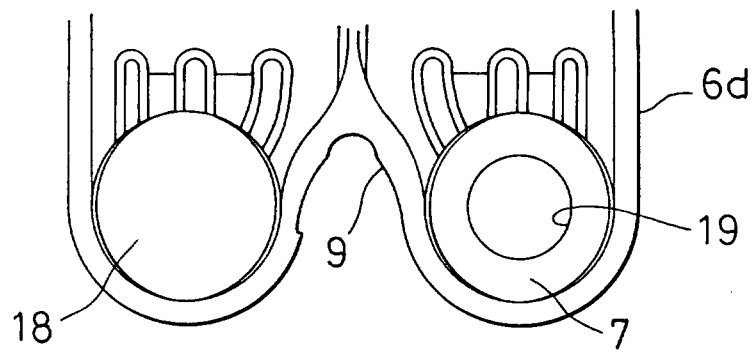


FIG.4C

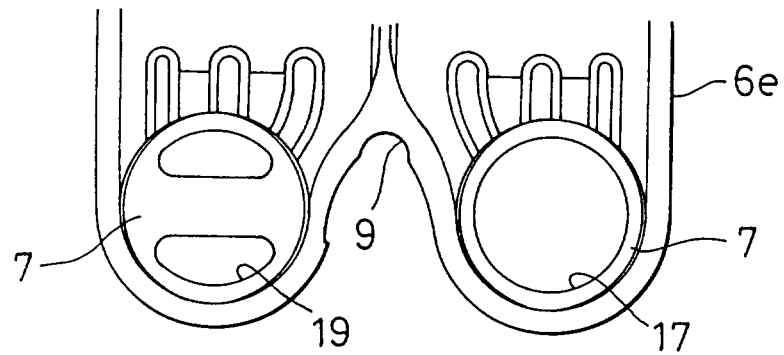


FIG.4D

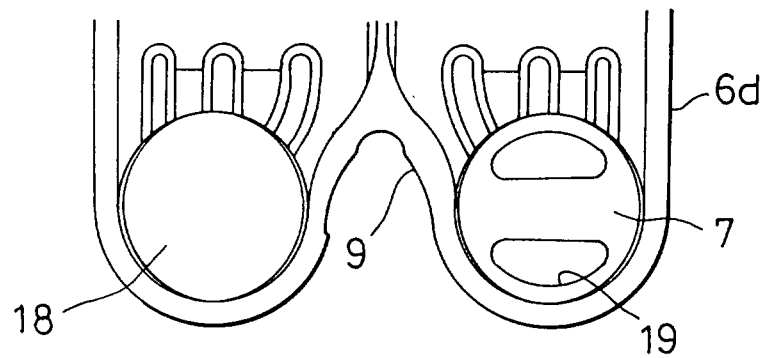


FIG.5A

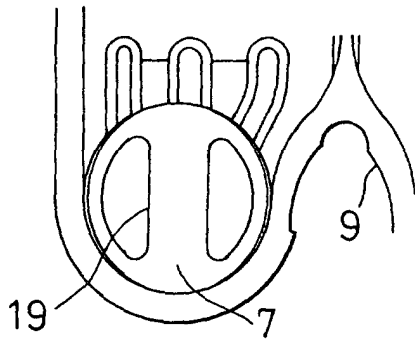


FIG.5D

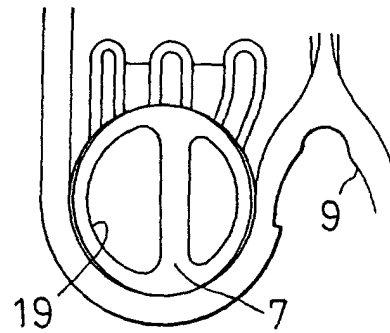


FIG.5B

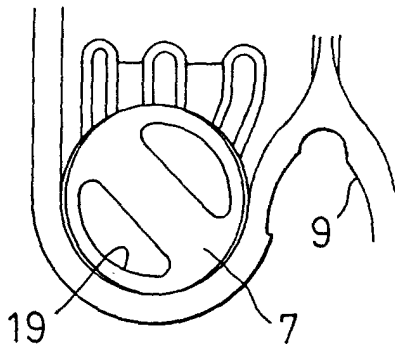


FIG.5E

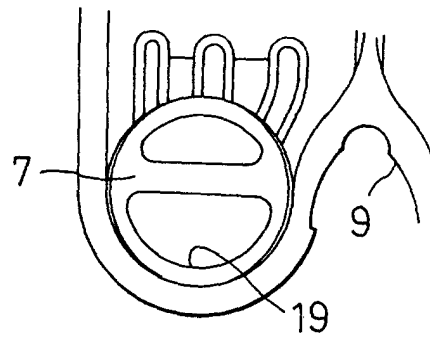


FIG.5C

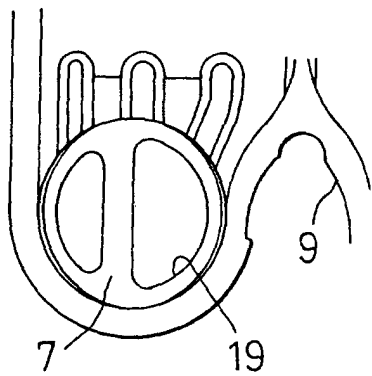


FIG.5F

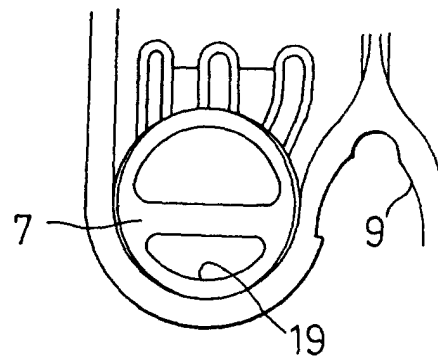


FIG.6A

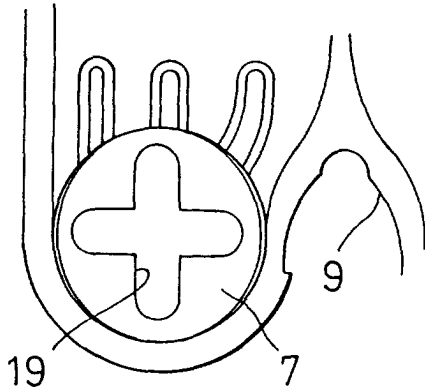


FIG.6B

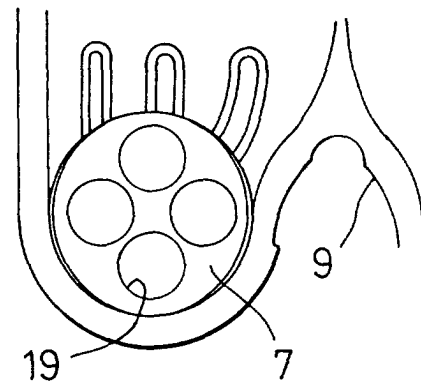


FIG.6C

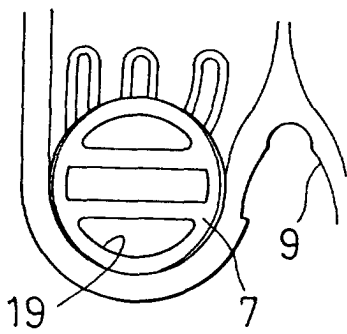


FIG.6D

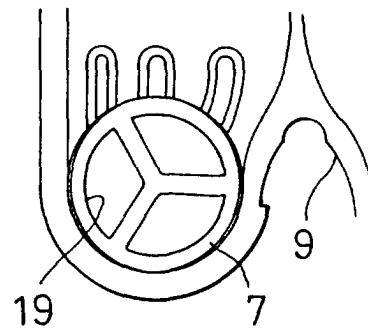


FIG.6E

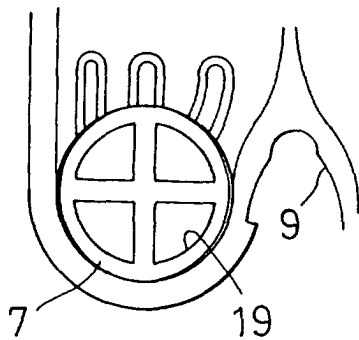


FIG.7

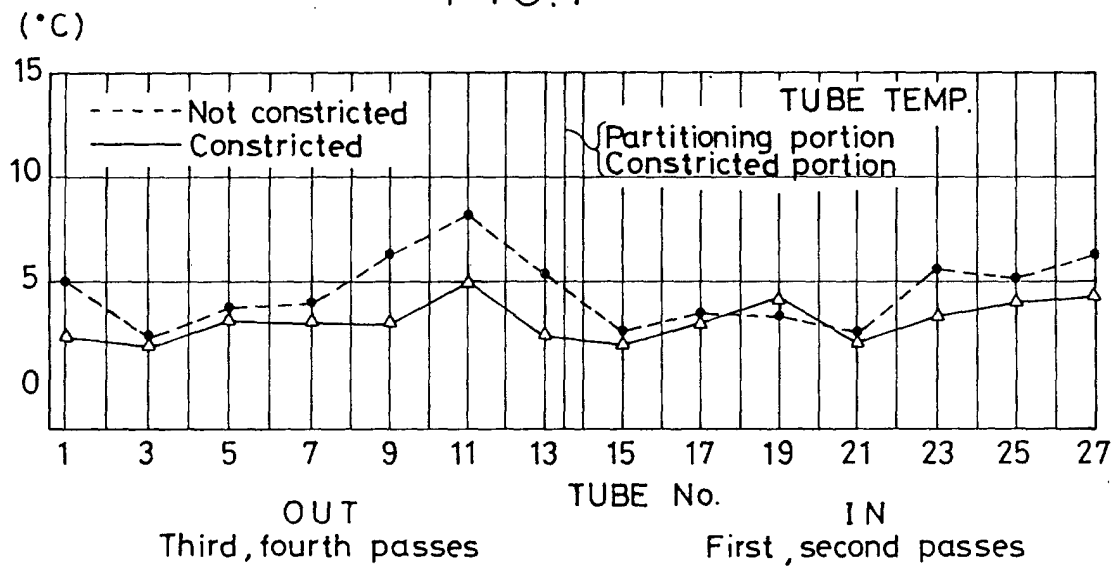


FIG.8A

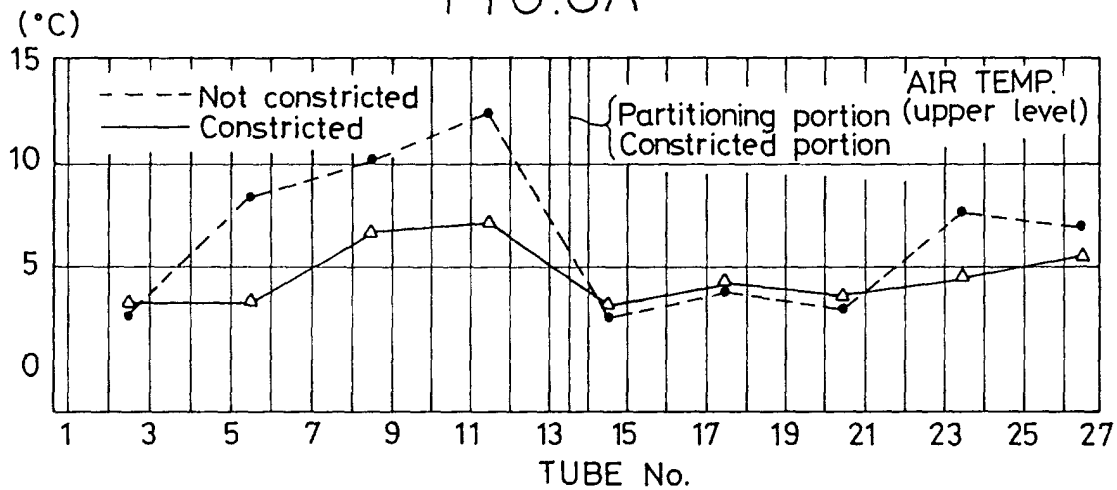


FIG.8B

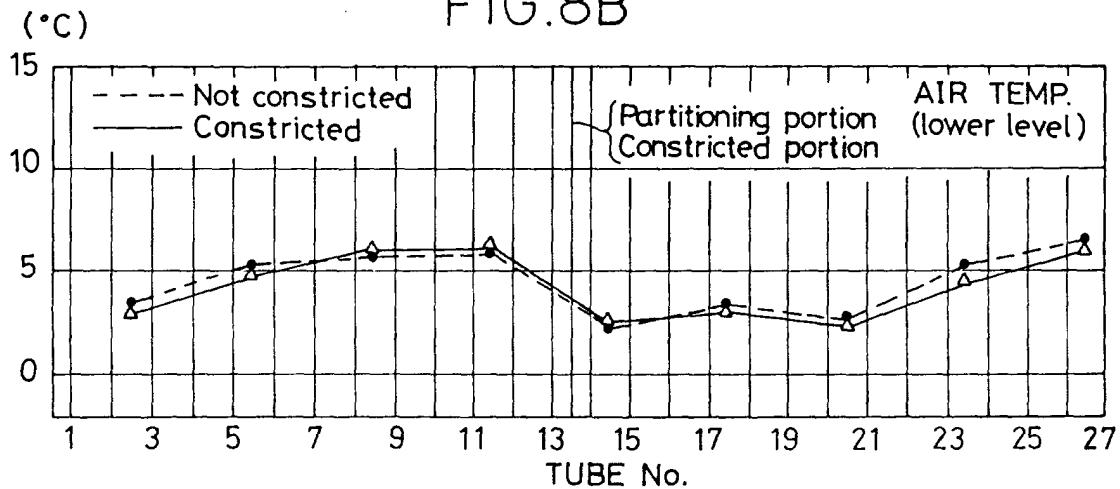


FIG.9A

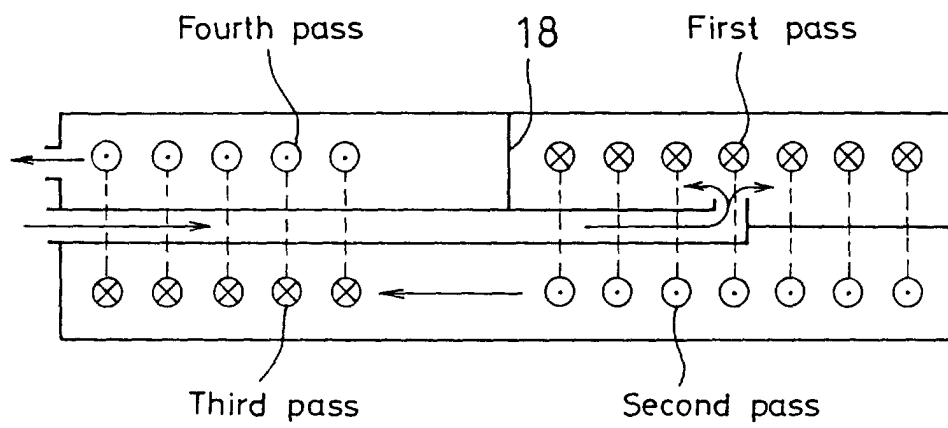
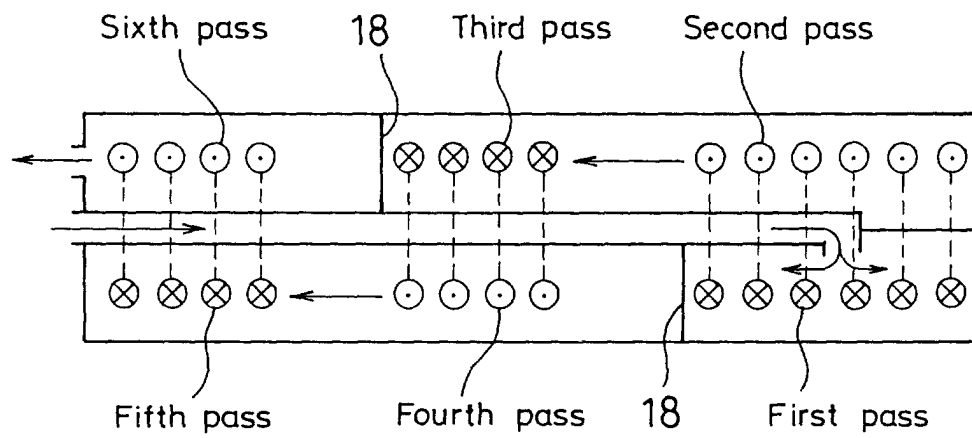


FIG.9B



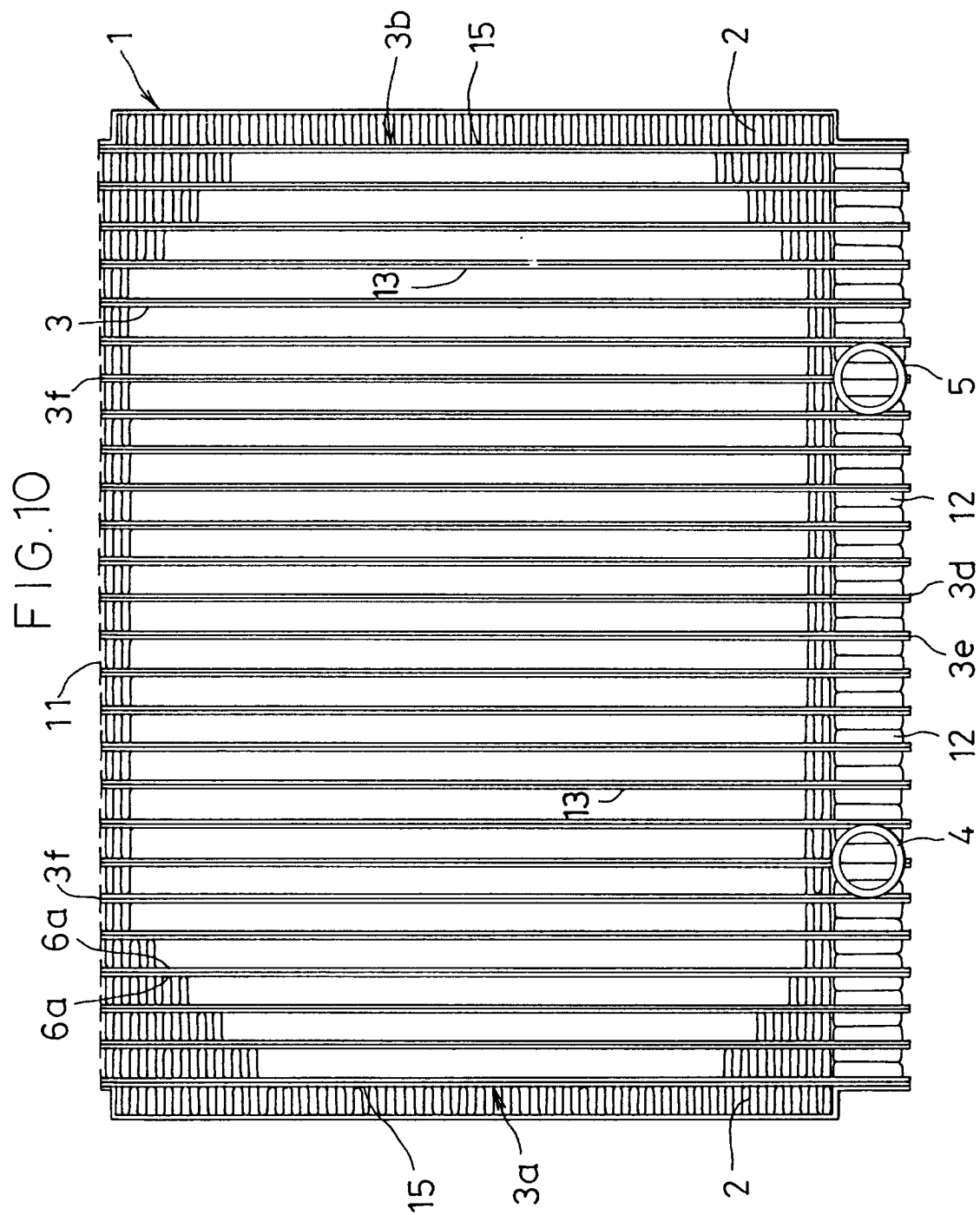


FIG.11A

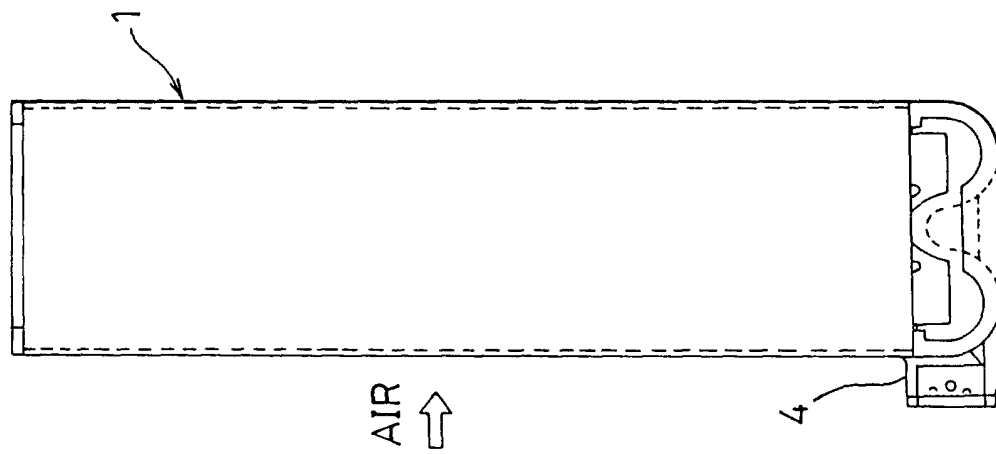


FIG.11B

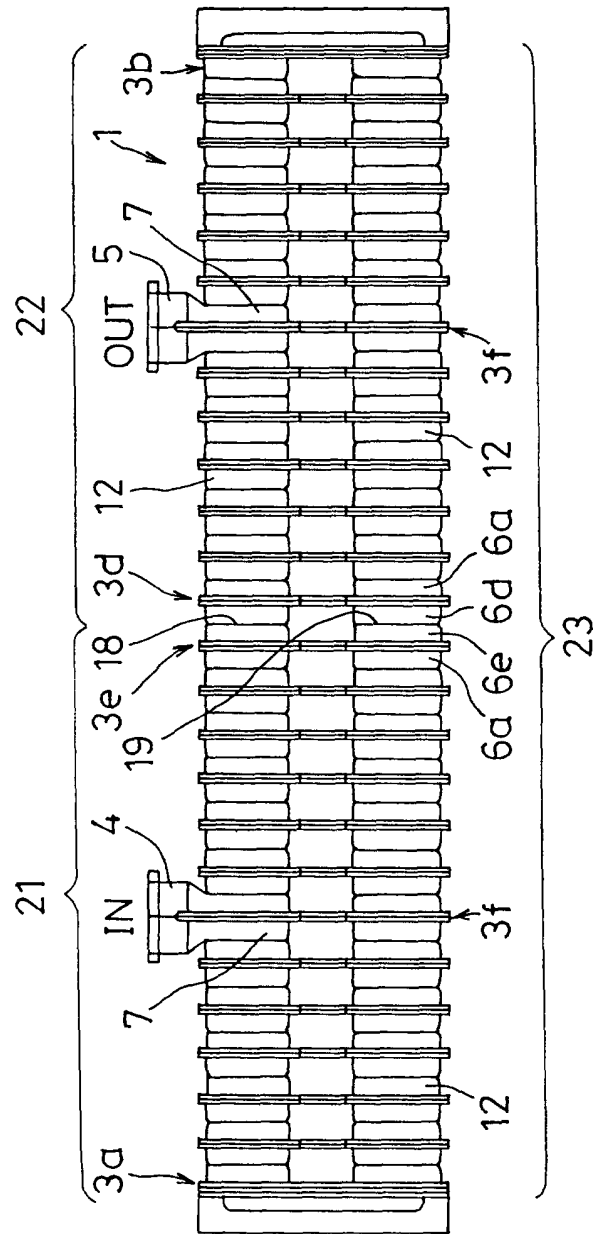


FIG.12A

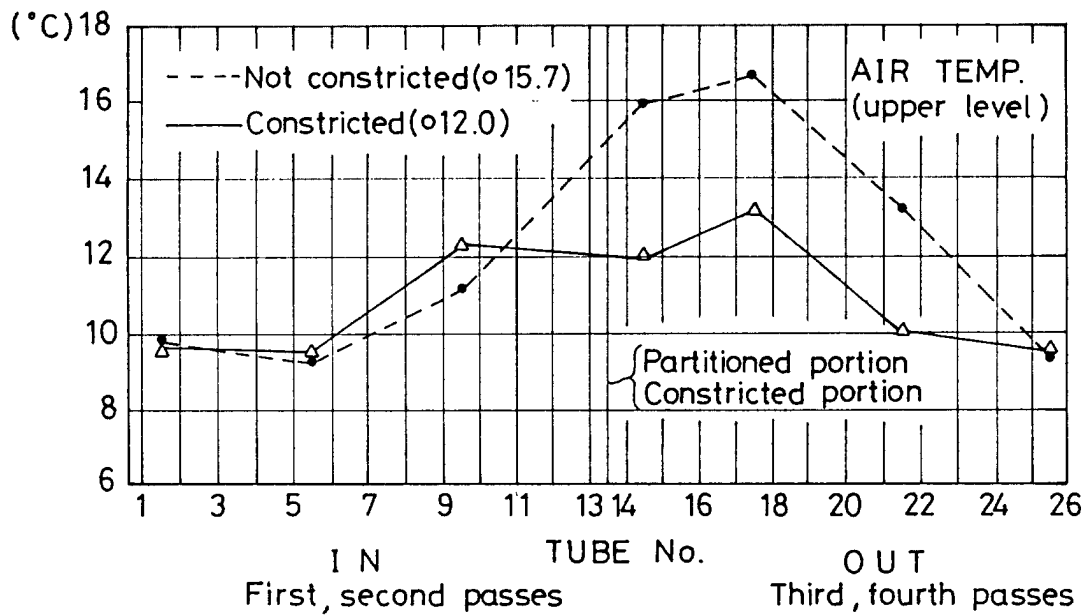


FIG.12B

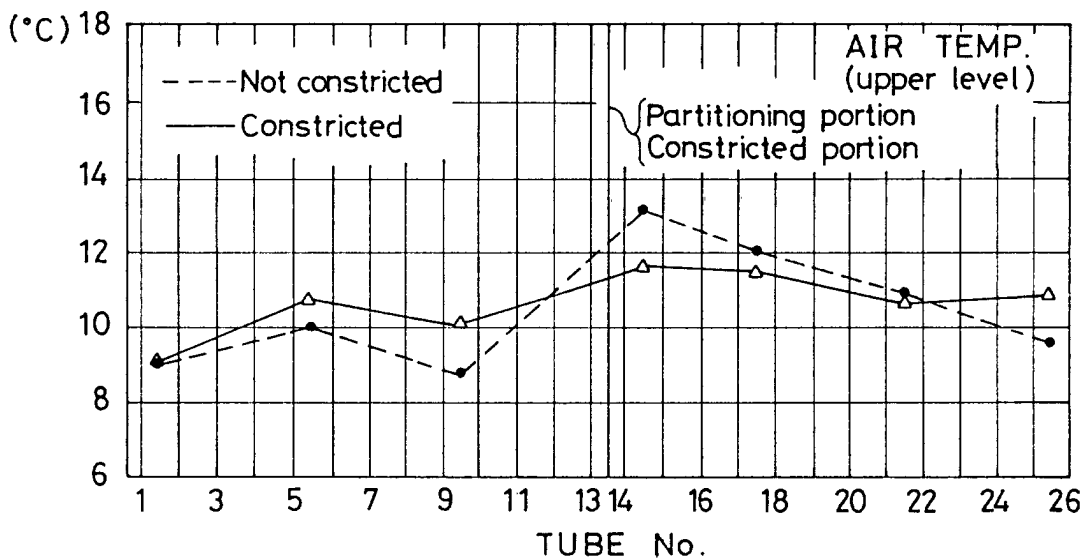


FIG.13

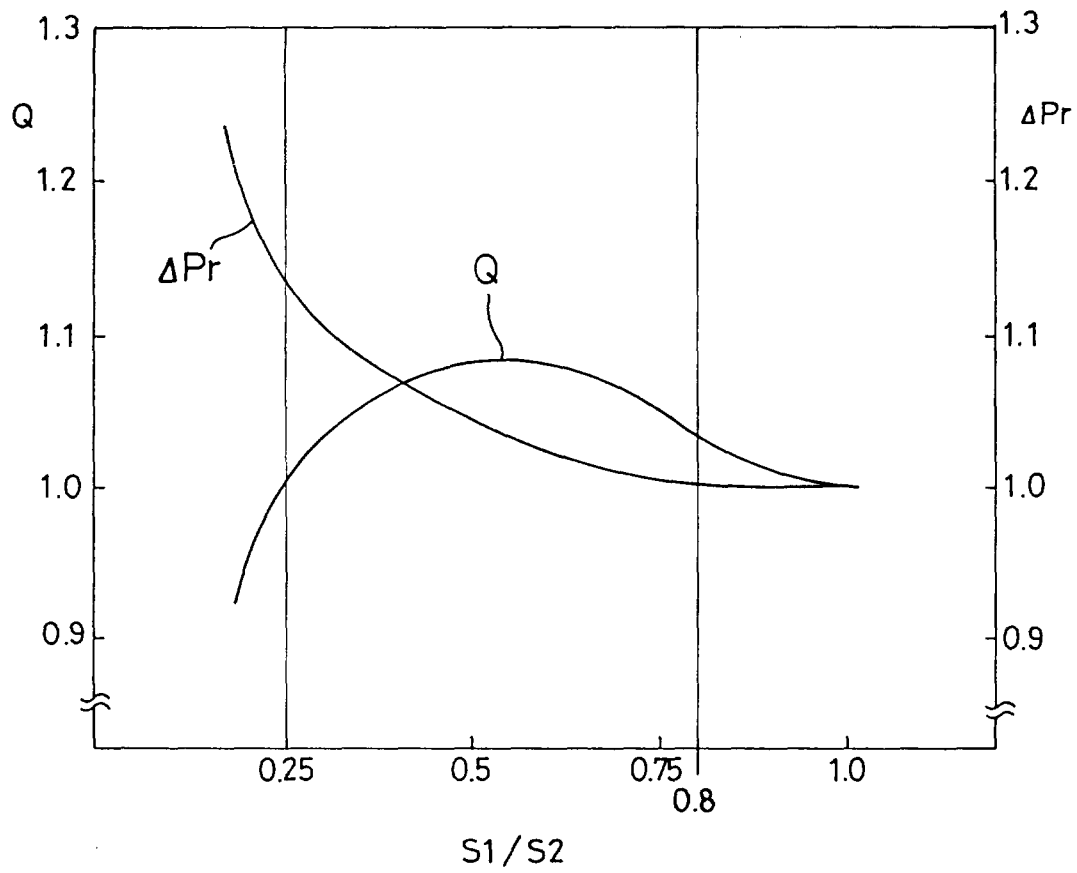


FIG.14

